Nantucket Harbor Water Quality
Annual Report
2003

Tracy Curley
Town Biologist
Marine & Coastal Resource Department
34 Washington Street
Nantucket, MA 02554

Introduction

Nantucket Harbor has an approximate surface area of 5,254 acres, a basin volume of 50,993 acre-feet, and a watershed area that is 5,340 acres in size (Knoecklein, 1998). Water quality has been monitored in Nantucket Harbor since 1990. Water quality in Nantucket Harbor has deteriorated over time.

There have been serious declines in water quality in all coastal communities due to nutrient overloading. Coastal ecosystems have the capacity to assimilate some level of nutrient input without major changes in the ecological health. Ecosystem damage is caused by the excessive inputs of nutrients from natural processes and from anthropogenic (man made) pressures.

As nitrogen and phosphorus concentrations increase, the natural eutrophication process is accelerated. This process results in excessive aquatic plant growth, particularly in poorly flushed, shallow coastal embayment. As this over abundant plant growth dies, its decomposition uses up the available dissolved oxygen and creates anoxic conditions. Nutrients are released from the sediments into the water column. The continued addition of nutrients and acceleration of plant growth leads to further decomposition by anaerobic bacteria (bacteria that don't require oxygen). The result is an embayment bottom coated with an organic mud residue (i.e. Wauwinet, Polpis, Quaise, Pocomo flats) and a habitat, once desirable for shellfish and finfish, now unsuitable for spawning and growth. If the water quality degrades to this point, aquatic life in the embayment is substantially diminished.

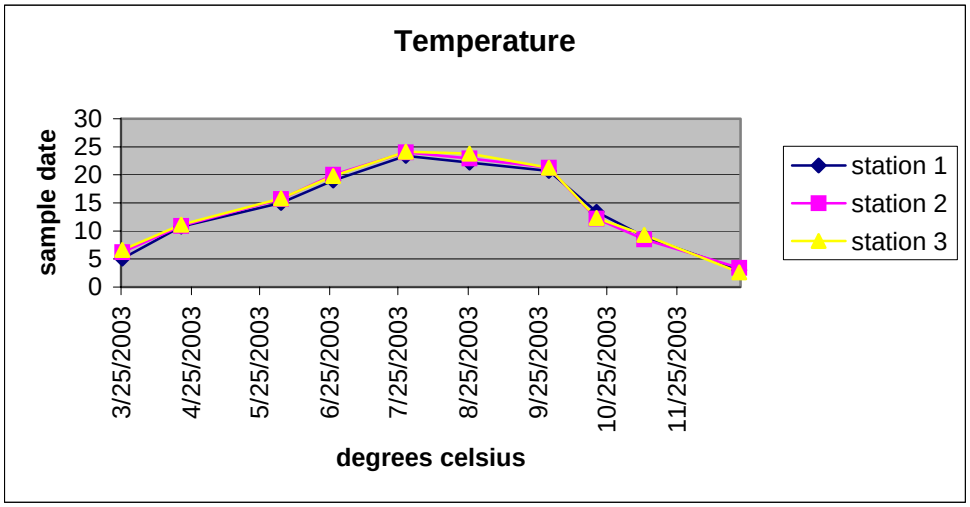
During the years 2000-2003, the Marine and Coastal Resource Department biologists, Tracy Curley and Keith Conant, gathered nutrient information for Nantucket harbor and its' watershed drainage basin. Harbor sampling includes temperature, dissolved oxygen, salinity, water transparency, water quality constituents (nitrogen and phosphorus), and phytoplankton. The water quality stations are as follows: **station 1 Mooring Field**, **station 2 Quaise Basin**, **station 3 Head of Harbor**, **station 4 Nantucket Sound**, **station 5 Polpis West**, and **station 6 Polpis East**.

Nantucket Harbor Monitoring Results:
Temperature and salinity:

To better understand nutrient loading and internal recycling, it is important to determine if sections of Nantucket Harbor stratify. Stratification generally results from a combination of physical and chemical parameters. Colder and more saline water sinks to the bottom of the water column. During the summer, biological respiration can have severe impacts on dissolved oxygen concentrations in the bottom layers of water. The normal impacts of stratifications in concert with increased nutrient loading will increase biological production and decreased dissolved oxygen levels in the bottom-stratified water. Low oxygen for long periods of time is detrimental to the benthic communities.

In 2003, Nantucket Harbor was frozen in February. Temperature in the spring was approximately 6C. Temperature increased throughout the summer and peaked in July at 24C. Temperatures remained high through the summer (20-21C) and began to decrease to a low of 3C in December for months sampled.

Figure 1: Average Water Temperature for Harbor Stations (Mooring Field, Quaise Basin and Wauwinet)



The total salinity differences between the surface and bottom layers of water represent a large density change. In March, a large salinity gradient was observed in Quaise (station 2) and Wauwinet (station 3). As air temperature warms in March, surface runoff increases causing a fresh water layer at the surface in Quaise and Wauwinet. Polpis Harbor has the largest stream discharge input to surface area with Quaise containing the second largest input ratio (WHOI 1997). Polpis West had a salinity gradient on the April sampling date. Polpis East and Quaise were observed to have a salinity gradient on the June 3rd sample date.

In September and October, an exchange of surface and bottom water occurred as water temperatures became almost isothermic. Less saline water was observed in the bottom layer of water in these months with the exception of Polpis East. To determine the vertical salinity difference, the surface water salinity is subtracted from the bottom salinity to determine a positive or negative number. A negative number indicates that the bottom water is less saline than the surface water. A positive number indicates that the bottom water is more saline that the surface.

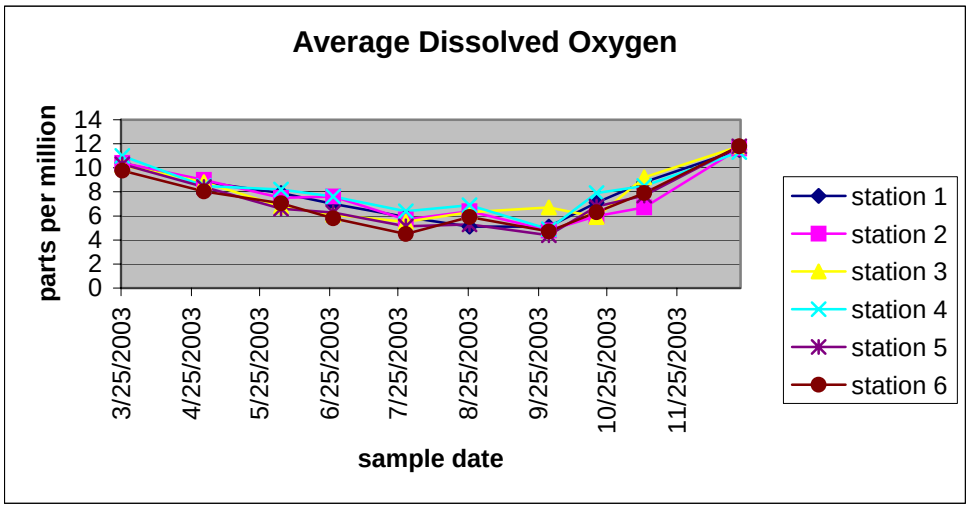
Table 1: Vertical Salinity Differences in Harbor Stations

Vertical Salinity Differences in Parts per Thousand

	3/25/2003	4/30/2003	6/3/2003	6/26/2003	7/28/2003	8/25/2003	9/29/2003	10/20/2003	11/10/2003	12/22/2003
station 1	0.2	0.1	0	0.3	0	0.1	-2	-5	0.2	0
station 2	22.9	0.2	0.3	0	0.1	0.1	-3	-7.2	-1.4	0.9
station 3	31.5	0	0	-0.1	0	0	-3.4	-3.4	0.2	0.2
station 4	0.5	0.2	0	-0.1	0	0.1	0	-0.8	0	0.2
station 5	0	2.5	0	0.4	-0.1	0	-0.8	-3.7	0	2.1
station 6	0.1	0	2.6	0.6	0.1	0	-1.4	7.1	-1	0.3

Dissolved Oxygen:
The physical effect of water temperature is also important when considering water quality. At high water temperatures, the solubility of oxygen is low and therefore the concentration of dissolved oxygen in the water column is reduced. Colder water contains more dissolved oxygen gas. During July, we would expect dissolved oxygen to be the lowest due to the high water temperature and the solubility of oxygen.

Figure 2: Average Dissolved Oxygen for Harbor Stations



In the months of June, July, August, and *September*, dissolved oxygen concentrations were hypoxic (4ppm – 6ppm) on the bottom. *In September the YSI meter may have*

malfunctioned. We recorded that in *September*, Quaise and Polpis Harbor stations had dissolved oxygen levels in the range of 4.41ppm to 4.92ppm. If dissolved oxygen readings are correct, these low dissolved oxygen levels depict an oxygen demand created by biological processes not the solubility of oxygen. In *September* at the mooring field, surface waters contained 4.92ppm of dissolved oxygen as did Quaise and Polpis Harbor. *September* had the lowest recorded dissolved oxygen concentrations throughout the water column. Salinity was also the lowest throughout the water column in September. The lower salinity would suggest that Nantucket Harbor received fresh water from the drainage basin during September.

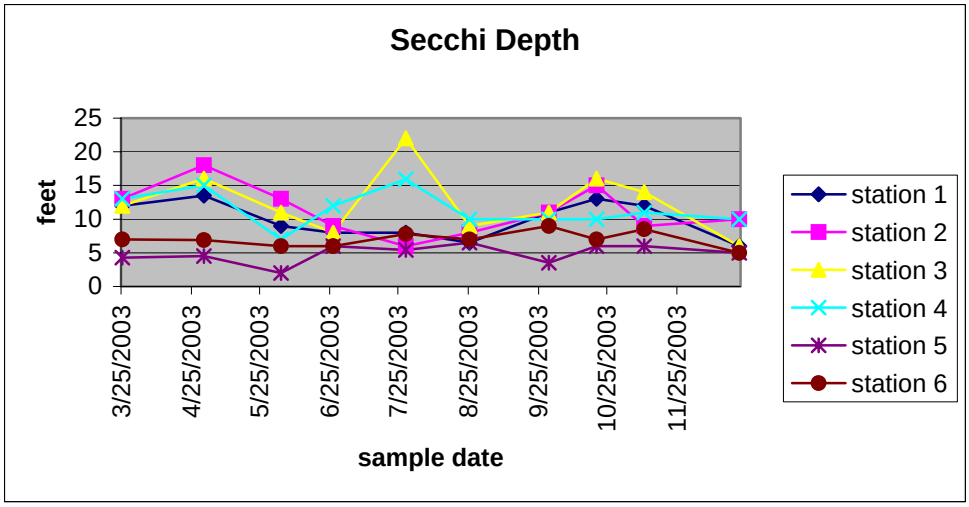
However, stream data suggests that September's fresh water input was low and the meter probably did malfunction during the September sampling event. This highest stream flow occurred in June of 2003. The increased freshwater from the drainage basin carried nitrogen and phosphorus to the harbor effecting dissolved oxygen concentrations in the water column in June and possibly July. The Nantucket Harbor Study conducted by WHOI in 1997 states that the percent stream flow into Nantucket Harbor is highest in Polpis Harbor and the Quaise Basin.

Secchi Depth
Secchi depth is an approximate measure of water transparency. The secchi depth is a measure of the quantity of particulate material suspended in the water column. Secchi depth is a good estimate of the density of phytoplankton populations.

Nantucket Harbor appeared to experience two periods of water clarity, in April and October. The Harbor water clarity was good between March and early May, reaching a maximum of 18ft, and then again in October reaching 15feet.

In June, the Head of the Harbor had hypoxic levels of dissolved oxygen in the bottom layer of water causing the possible internal recycling of nutrients and resultant phytoplankton bloom. In July, Wauwinet and Nantucket Sound had the greatest water clarity of all sites sampled for the year. The water cleared in July in the head of the harbor after a possible phytoplankton bloom in June.

Figure 3: Secchi Depth for Harbor Stations



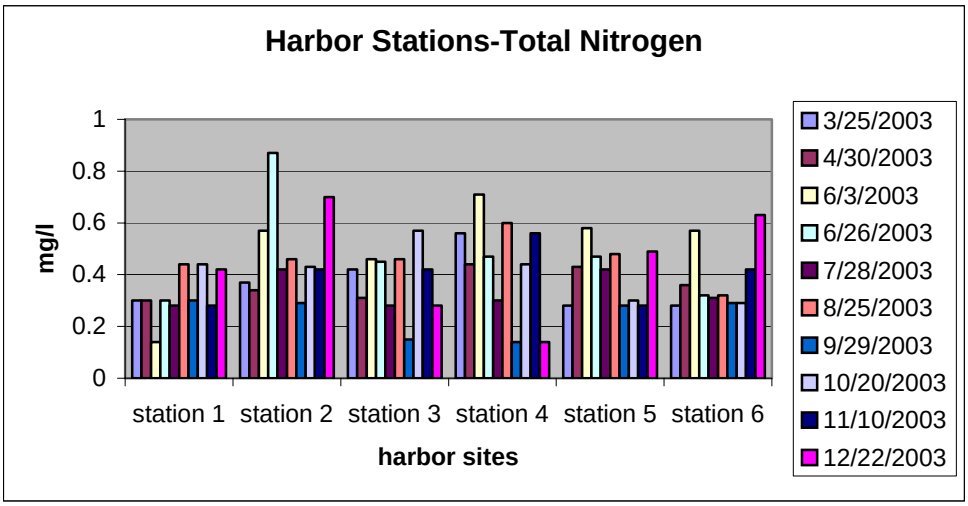
The pattern of alternating periods of good and poor water clarity appears to be a trend in Nantucket Harbor. Generally, water transparency reaches a maximum in April and again in November. Secchi depth generally reaches a low in February and July. The winter secchi minimum corresponds to a diatom bloom and in the summer a dinoflagellates bloom results in a decrease in secchi depth in most stations as nutrient concentrations increase.

Nutrient Data:

Nitrogen

Nantucket Harbor is a marine system and therefore is nitrogen limited. It is nitrogen that determines the amount of plants (phytoplankton, submerged aquatic vegetation) than can grow. Blooms of bluegreen algae and other detrimental algae proliferate when too much dissolved inorganic nitrogen is present in the water body. Inorganic nitrogen is comprised of nitrite, nitrate, and ammonia. Nitrogen has a complex set of oxidation states in water that can yield a number of different forms of nitrogen. Generally total nitrogen above 600 ppb (0.6mg/l) and dissolved inorganic nitrogen above 150 ppb (0.15mg/l) indicate eutrophic water.

Figure 4: Total Nitrogen



The mooring field station had a total nitrogen range from 0.14 mg/l to 0.44 mg/l for the sample year. In the months of August through December, total nitrogen alternated between 0.28 mg/l to 44 mg/l but did not reach eutrophic levels. The Quaise station had a total nitrogen range from 0.29 mg/l to 0.87 mg/l. Total nitrogen in Quaise reached eutrophic levels in June and December. Wauwinet had a total nitrogen range from 0.15 mg/l to 0.57mg/l. Nantucket Sound had high total nitrogen levels ranging from 0.14 mg/l to 0.71 mg/l. Total nitrogen was low in December in the Sound. Polpis West had higher total nitrogen levels than Polpis East with the exception of December. Polpis Harbor did not exceed eutrophic levels as it pertains to nitrogen. Total nitrogen peaked at different times for each station. The nitrate and nitrite fractions were tested together so all nitrate data includes nitrite. Nitrate for the 2003 sample year did not exceed the eutrophic threshold.

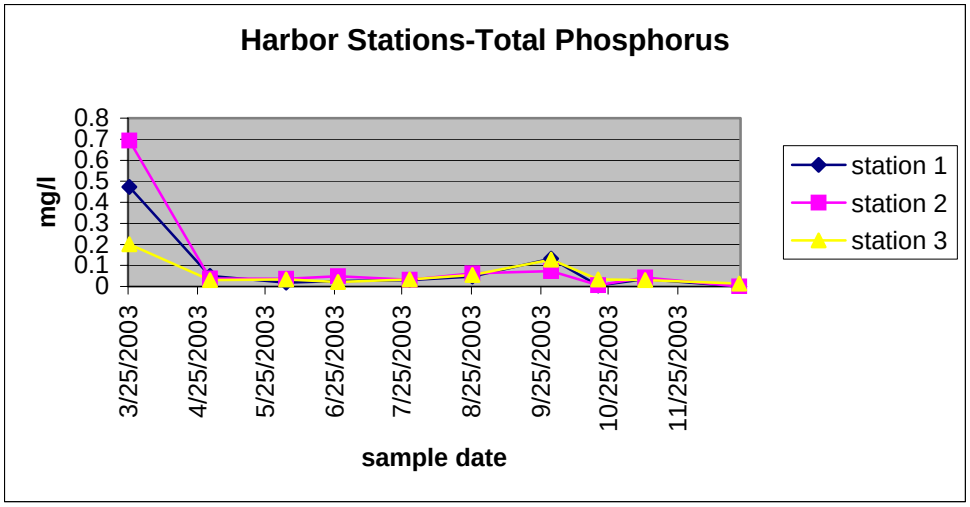
Phosphorus

Phosphorus was initially made available to living organisms through the weathering of rocks. Phosphorus is found in the environment as a form of soluble phosphate ions.

Phosphate, which is applied to a lawn as fertilizer, becomes bound to soil particles. Phosphorus is a major eutrophication contaminant in surface water of fresh water bodies. Principal loading is due soil erosion. Phosphorus can enter the harbor through groundwater.

To date, phosphorus concentrations have exceeded (0.05 mg/l) on more than one occasion since 1998 indicating enriched conditions. Phosphorus concentrations are rising with more frequency at more sample stations.

Figure 5: Phosphorus



Total phosphorus was measured March through December. Phosphorus is generally detected in low concentration during the winter. Phosphorus generally increases in the spring, early summer and fall. Phosphorus concentrations peaked twice this year. The highest concentrations were found in March and September. Phosphorus concentrations were also high, exceeding eutrophic levels in four stations, in August.

The phosphorus in the Head of the Harbor (station 3) is most likely a result of stream flow only. The Head of the harbor generally increases gradually in phosphorus throughout the spring, summer, and fall. This year, phosphorus peaked in March and again in September.

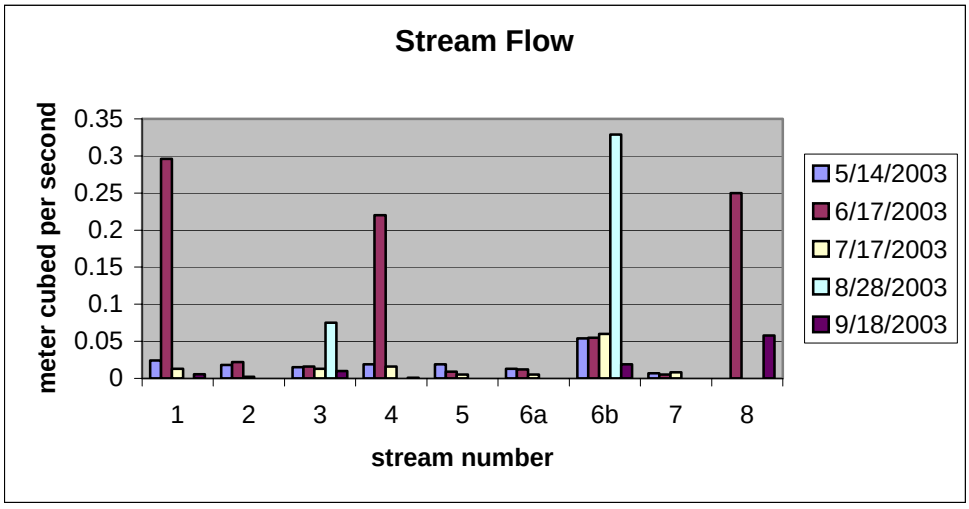
Quaise Basin (station 2) generally had higher phosphorus than head of the harbor (station 3). However, the stable concentrations of phosphorus may be the result of septic systems. Conversely, spikes of phosphorus measured in the summer and fall are most probably the result of fertilizer application.

As stream velocity increase in the spring, the result is increased sedimentation. Phosphorus remains bound to the sediments until carried by storm water or ground water

flows. The reduction in phosphorus concentration during the end of July and August correlate with reduced groundwater flow.

Stream Data:
For sample dates, June and August had the greatest flow of water for all streams. To measure drainage basin characteristics, the water quality constituents in nine streams extending from Wauwinet to the Life Saving Station are sampled. **Stream 1** flows into Head of Harbor from a wetland off Wauwinet Road. **Stream 2** flows into Meadowi Creek (Pocomo Meadow salt marsh) near Chaos Corner. **Stream 3** flows into Polpis Harbor East from a connected small pond off Wauwinet Road. **Stream 4** drains cranberry bogs into Polpis Harbor East. **Stream 5** drains a swamp near the cemetery flows into Polpis West. **Stream 6** drains a wetland/swamp with flow into southern most portion of Polpis West. **Stream 6.5** drains wetland/swamp with flow into southern most portions of Polpis West. **Stream 7** drains a small wetland area, which flows into Folgers salt marsh. **Stream 8** is tidally connected to Folgers Marsh, drains wetland (Life Saving Museum).

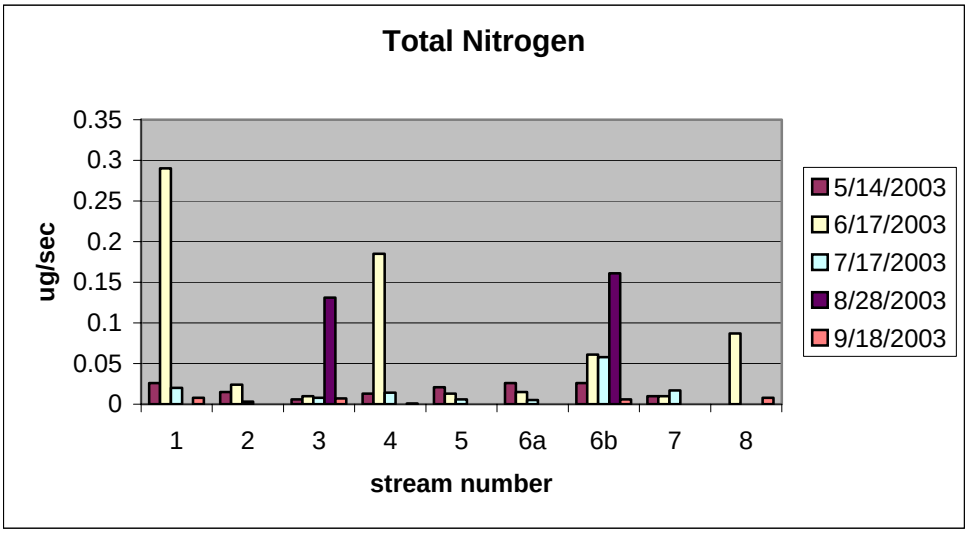
Figure 6: Stream Flow in m3/sec



Nitrate was analyzed for streams from May through September. With the exception of stream 3 and 6a, nitrate was below detection for all sample dates. Stream 3 has had consistently high nitrogen and phosphorus inputs since 1998. Stream 6a contained 100 ppb of nitrate on June 17th. Organic nitrogen in the nine streams was high ranging from 0.14 mg/l to 2.03mg/l as a discrete sample. High levels of organics are expected since most of the streams drain wetland areas. Ammonia nitrogen in the most surface streams was below detection during 2003. Some higher levels (140 ppb) were detected in May in streams 5, 6a, and 7 and again in August in stream 4. Streams 1, 3, 4, 6b, and 8 contained the highest concentrations of total nitrogen flowing into the harbor when calculating flow rates and nitrogen concentrations. Stream 1 carried 0.29 ug of total nitrogen per second into the Head of the Harbor on sample date June 17th. Stream 4, which drains the cranberry bog, also had high concentrations of nitrogen flowing at 0.185 ug/second on June 17th. Stream 4 flows into Polpis East. Total nitrogen peaked for the year in Polpis

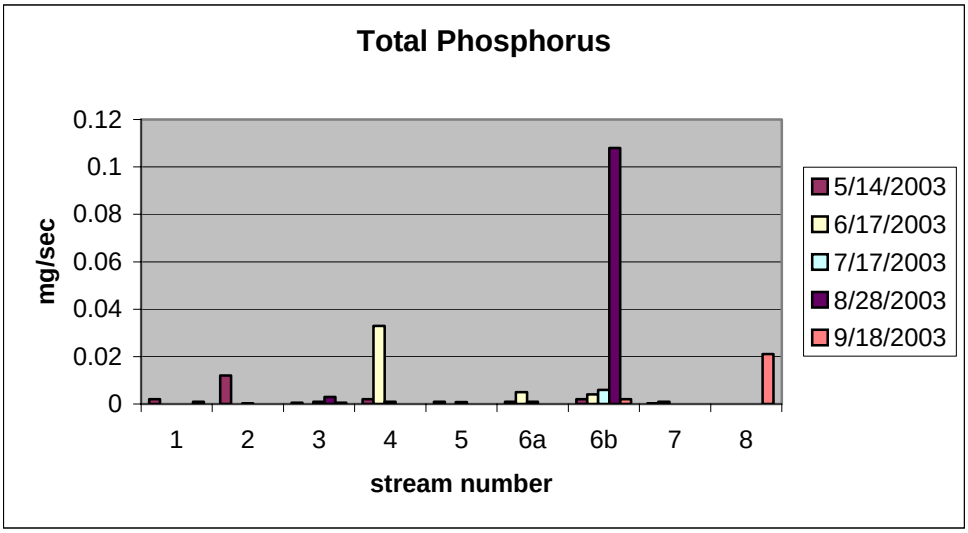
East and West on the June 3 harbor sampling date. Nitrogen decreased slightly at the end of June and into July in Polpis East.

Figure 7: Total Nitrogen for Stream Flow



Phosphorus flowing into Nantucket Harbor was lower this year than in the past. Stream 2 contained 0.012 ug/sec of total phosphorus in May. Stream 4 contained 0.033 ug/sec of phosphorus in June. Stream 6b had very high phosphorus (0.108 ug/sec) concentrations in August. Stream 8 had 0.021ug/sec of phosphorus in September. Polpis West water quality station increased from 0.057 mg/l in August to 0.067 mg/l of phosphorus in September. Phosphorus decreased at the Polpis West water quality station in October.

Figure 8: Total Phosphorus for Stream Flow



Benthic Communities:

In order to truly access the water quality in Nantucket Harbor, an assessment of the plants and animals (benthic communities) must be made in addition to water chemistry. In the summer of 2003, students of SMAST in coordination with the DEP Estuaries Project took core samples in Nantucket Harbor for benthic analysis. Results of these finding should be available in June 2004.